Condition of Lake Erie Largemouth Bass Sampled in the ODOW Nearshore Community Survey 2013-2017

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Data Prep

```
Stock <- read.csv("Data/Clean-Data/largemouth-bass_Wr_Stock.csv") %>%
  filter(Year < 2017) %>%
  filterD(!is.na(Wr)) %>%
  arrange(Year,gcat)


Stock$fyr <- factor(Stock$fyr)
Stock$Year <- factor(Stock$Year)
```

```
headtail(Stock)
```

```
##     fyr Year Site FID Weight        Ws        Wr Length lcat20      gcat
## 1    13 2013   10   9    807  874.1340  92.31995    387    380 preferred
## 2    13 2013   11   1    968  934.6786 103.56501    395    380 preferred
## 3    13 2013   11   8   1159 1196.8993  96.83354    426    420 preferred
## 408  16 2016   18   8    479  336.1388 142.50066    289    280     stock
## 409  16 2016   18  14    466  351.6072 132.53427    293    280     stock
## 410  16 2016   18  23    473  375.7265 125.88945    299    280     stock
##     Age SexCon Sex
## 1     4      8   2
## 2     3      3   1
## 3     3      3   1
## 408   2      3   1
## 409   2      3   1
## 410   2      8   2
```

```
str(Stock)
```

```
## 'data.frame':    410 obs. of  13 variables:
##  $ fyr   : Factor w/ 4 levels "13","14","15",..: 1 1 1 1 1 1 1 1 1 1 ...
##  $ Year  : Factor w/ 4 levels "2013","2014",..: 1 1 1 1 1 1 1 1 1 1 ...
##  $ Site  : int  10 11 11 15 15 15 15 15 18 18 ...
##  $ FID   : int  9 1 8 167 NA 170 176 180 142 141 ...
##  $ Weight: int  807 968 1159 1144 927 982 1015 1000 942 941 ...
##  $ Ws    : num  874 935 1197 859 882 ...
##  $ Wr    : num  92.3 103.6 96.8 133.1 105.2 ...
##  $ Length: int  387 395 426 385 388 401 406 411 381 382 ...
##  $ lcat20: int  380 380 420 380 380 400 400 400 380 380 ...
##  $ gcat  : Factor w/ 3 levels "preferred","quality",..: 1 1 1 1 1 1 1 1 1 1 ...
##  $ Age   : int  4 3 3 3 NA 4 5 5 3 3 ...
##  $ SexCon: int  8 3 3 3 3 8 8 8 8 3 ...
##  $ Sex   : int  2 1 1 1 1 2 2 2 2 1 ...
```

```
unique(Stock$fyr)
```

```
## [1] 13 14 15 16
## Levels: 13 14 15 16
```

Note

I removed the years 2012 and 2017. 2012 because only large fish have weight length data and more and differenct sites were samples. I removed 2017 due to differences in the survey.

Note

I am removing a fish from site 15 year 2013 because it appears to be a outlier (Wr > 200). Probably due to data entry error. **I went back and did this in 'Create-Wr-Gabelhouse-Data.Rmd' where I make the data file I use for this analysis.**

Summarize Relative Weight by Year

```
(Wr.Stock <- Summarize(Wr ~ Year, data = Stock) %>% arrange(Year))
```

```
##   Year   n     mean       sd   min     Q1 median    Q3   max
## 1 2013  97 113.3837 13.28398 76.14 104.40  113.0 122.2 143.8
## 2 2014 140 109.6148 15.74476 80.40  98.78  106.9 117.8 151.3
## 3 2015  67 109.8376 15.57996 78.22  98.53  108.6 120.8 149.8
## 4 2016 106 115.4942 13.83934 61.76 108.00  115.5 124.7 146.2
```

Note

The relative weight data contains only stock length individuals. This is so that I can easily compare the relative weight of fish with PSD. This is done despite the min TL being 150 mm. I may want to summarize relative weight for 150mm and greater length individuals in the future to see if young/small fish drive down or increase Wr.

Lets start exploring the relative weight data. I have two questions I would like to know the answer to.

1) does Wr differ among years?
2) does Wr differ among gabelhouse length categories?

First Lets see if Wr is different between years.

```
aov1 <- lm(Wr ~ Year, data = Stock)
# save(aov1,file = 'model-output/aov1.rda')
Anova(aov1)
```

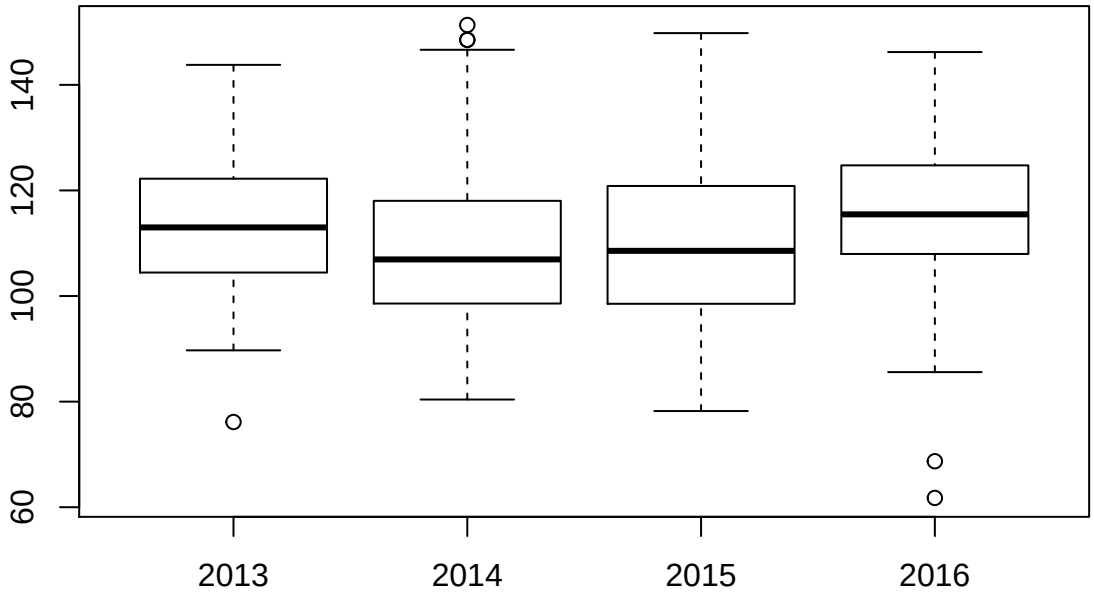
```
## Anova Table (Type II tests)
##
## Response: Wr
##           Sum Sq  Df F value   Pr(>F)
## Year        2588   3  4.0016 0.007933 **
## Residuals  87529 406
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
summary(aov1)
```

```
##
## Call:
## lm(formula = Wr ~ Year, data = Stock)
```

```
##
## Residuals:
##     Min      1Q  Median      3Q     Max
## -53.733  -9.356  -1.165   9.300  41.716
##
## Coefficients:
##             Estimate Std. Error t value Pr(>|t|)
## (Intercept)  113.384      1.491  76.054   <2e-16 ***
## Year2014      -3.769      1.940  -1.943   0.0527 .
## Year2015      -3.546      2.332  -1.520   0.1292
## Year2016       2.110      2.063   1.023   0.3069
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 14.68 on 406 degrees of freedom
## Multiple R-squared:  0.02872,    Adjusted R-squared:  0.02154
## F-statistic: 4.002 on 3 and 406 DF,  p-value: 0.007933
```

```
boxplot(Wr ~ Year, data = Stock)
```



```
mc1 <- glht(aov1, mcp(Year = "Tukey"))
summary(mc1)
```

```
##
##   Simultaneous Tests for General Linear Hypotheses
##
## Multiple Comparisons of Means: Tukey Contrasts
##
##
## Fit: lm(formula = Wr ~ Year, data = Stock)
##
## Linear Hypotheses:
##                   Estimate Std. Error t value Pr(>|t|)
## 2014 - 2013 == 0  -3.7690     1.9397  -1.943   0.2102
## 2015 - 2013 == 0  -3.5461     2.3324  -1.520   0.4242
## 2016 - 2013 == 0   2.1104     2.0631   1.023   0.7346
## 2015 - 2014 == 0   0.2228     2.1812   0.102   0.9996
## 2016 - 2014 == 0   5.8794     1.8904   3.110   0.0108 *
## 2016 - 2015 == 0   5.6566     2.2916   2.468   0.0656 .
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
## (Adjusted p values reported -- single-step method)
```

Looks like Wr *is significantly different* between years (One-Way ANOVA, $F_{3,406} = 4.00$, p = 0.007933). There is *no significant difference* in relative weight between 2013 and 2014 (Tukey HSD, t = -1.94, p = 0.2101), 2013 and 2015 (Tukey HSD, t = -1.52, p = 0.4241), 2013 and 2016 (Tukey HSD, t = 1.02, p = 0.7346), 2015 and 2014 (Tukey HSD, t = 0.10, p = 0.9996), and 2015 and 2016 (Tukey HSD, t = 2.47, p = 0.0656). However, relative weight *is significantly different* between 2014 and 2016 (Tukey HSD, t = 3.11, p = 0.0107).

constructing a plot of Wr and Year

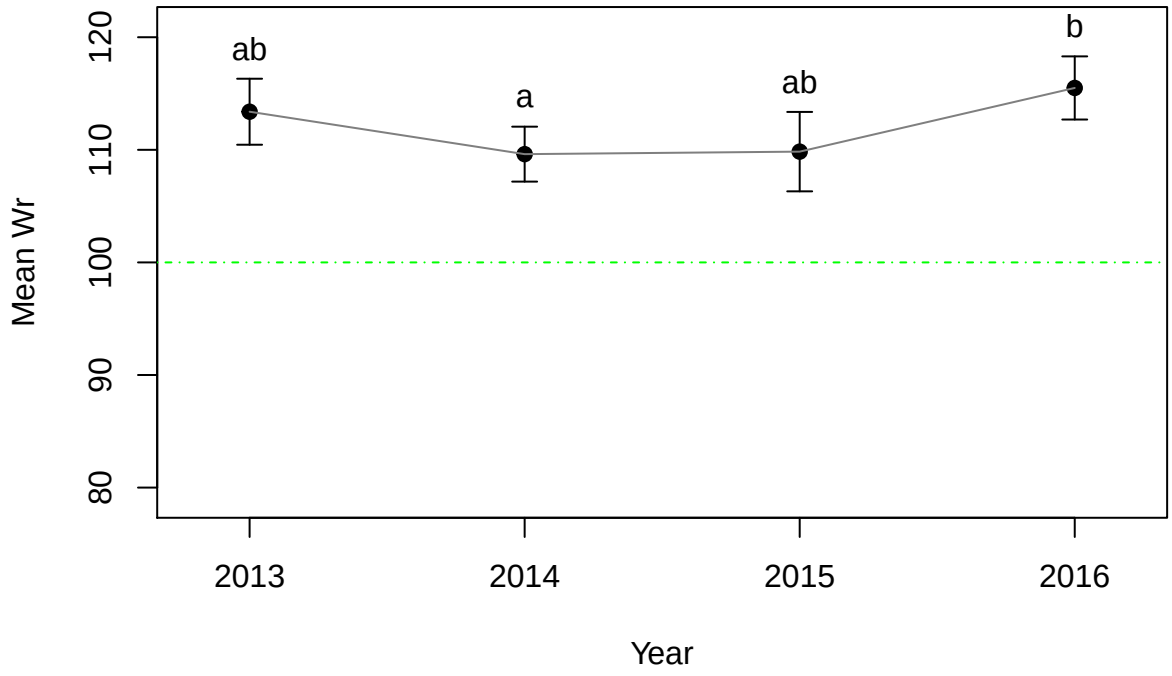
```
grps.1 <- c("2013", "2014", "2015", "2016")
nd.1 <- data.frame(Year = factor(grps.1, levels = grps.1))
(pred.1 <- predict(aov1, nd.1, interval = "confidence"))
```

```
##        fit      lwr      upr
## 1 113.3837 110.4530 116.3144
## 2 109.6148 107.1753 112.0542
## 3 109.8376 106.3113 113.3639
## 4 115.4942 112.6906 118.2977
```

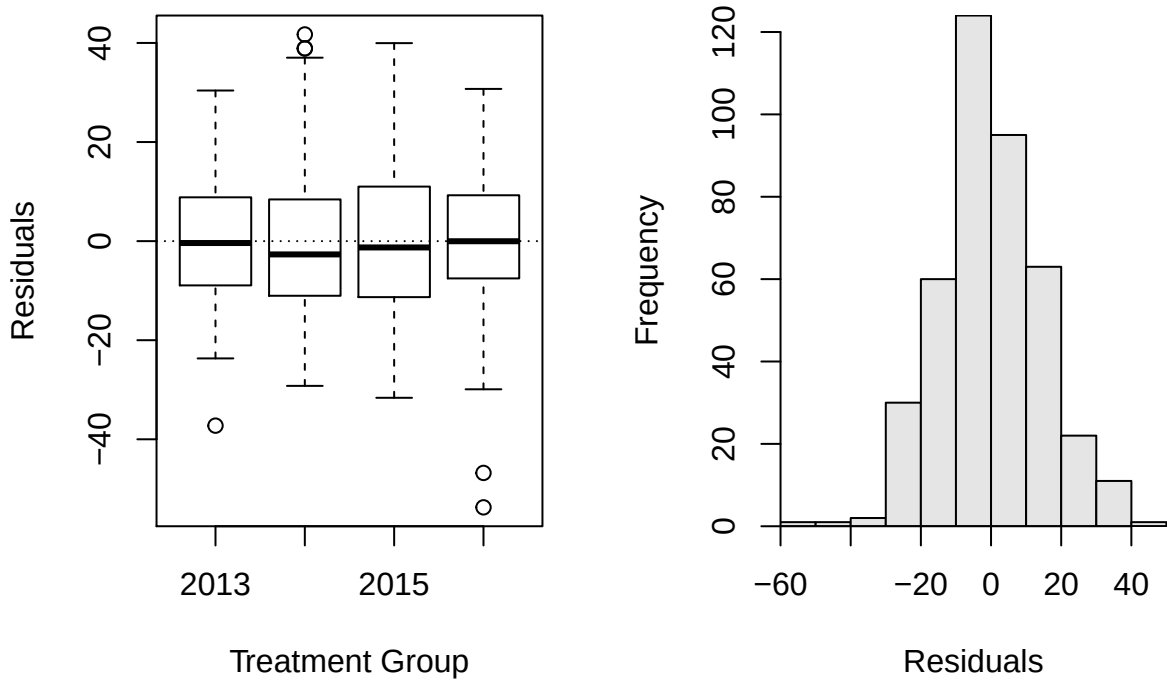
```
plotCI(as.numeric(nd.1$Year), pred.1[, "fit"], li = pred.1[, "lwr"], ui = pred.1[,
    "upr"], pch = 19, xaxt = "n", xlim = c(0.8, 4.2), ylim = c(79, 121), xlab = "Year",
    ylab = "Mean Wr")

lines(nd.1$Year, pred.1[, "fit"], col = "gray50")

axis(1, at = nd.1$Year, labels = nd.1$Year)

cld(mc1)
```

```
## 2013 2014 2015 2016
## "ab"  "a" "ab"  "b"
```

```
text(x = nd.1$Year, y = pred.1[, "upr"], labels = c("ab", "a", "ab", "b"), pos = 3)

abline(h = 100, lty = 4, col = "green")
```




```
residPlot(aov1)
```



```
leveneTest(aov1)  # Pitential outlier line 43
```

```
## Levene's Test for Homogeneity of Variance (center = median)
##        Df F value Pr(>F)
## group   3  1.5423  0.203
##       406
```

```
# 2013 site 15 Weight = 1714 Length = 368 Wr > 200
```

Variance are equal and the homoscedasticity assumption is likley met (Levene's Test, $F_{3,406} = 1.5423$, p = 0.203).

Without 2017 *Variance are equal and the homoscedasticity assumption is likley met (Levene's Test, $F_{2,311} = 1.75$, $p = 0.18$).*

```
Year <- c("2013", "2014", "2015", "2016")
pred.1 <- data.frame(Year, pred.1)
names(pred.1) <- c("Year", "Wr", "LCI", "UCI")
str(pred.1)
```

```
## 'data.frame':    4 obs. of  4 variables:
##  $ Year: Factor w/ 4 levels "2013","2014",..: 1 2 3 4
##  $ Wr  : num  113 110 110 115
##  $ LCI : num  110 107 106 113
##  $ UCI : num  116 112 113 118
```

```
head(pred.1)
```

```
##   Year       Wr      LCI      UCI
## 1 2013 113.3837 110.4530 116.3144
## 2 2014 109.6148 107.1753 112.0542
## 3 2015 109.8376 106.3113 113.3639
## 4 2016 115.4942 112.6906 118.2977
```

```
# 2-9-2018#write.csv(pred.1,file =
# 'Data/Clean-Data/summary-data/relative-weight_largemouth-bass_STOCK.csv',row.names
# = FALSE)
```

2) Wr and Gcat

I will look into the difference in Wr between gcat at a later date. I don't think this matters so much as of now.

```
##  Year      gcat  n   mean    sd    min     Q1 median    Q3   max
##  2013 preferred 16 106.85 11.41  92.32  98.65 104.40 114.4 133.1
##  2014 preferred 18  97.67  8.94  83.65  90.40  98.58 103.0 115.5
##  2015 preferred 15  97.09 12.45  78.22  86.01  96.69 105.6 119.8
##  2016 preferred 10 107.72  7.17  94.36 104.30 107.80 111.7 118.9
##  2013   quality 40 108.20 11.40  76.14 103.60 107.70 116.6 131.3
##  2014   quality 57 103.51 11.64  80.40  96.07 102.20 111.6 133.1
##  2015   quality 38 109.32 12.92  84.02 100.80 108.10 120.5 131.0
##  2016   quality 44 111.22 14.36  61.76 105.50 110.50 118.9 146.2
##  2013     stock 41 120.99 12.03  94.13 113.20 120.80 128.4 143.8
```

```
##  2014     stock 65 118.27 15.78  88.74 106.70 116.10 127.5 151.3
##  2015     stock 14 124.90 12.56 103.80 116.60 123.90 133.9 149.8
##  2016     stock 52 120.60 12.54  68.71 113.90 121.60 127.1 144.9
```

IDK this doesn't look quite right below

```
gcat.aov <- aov(Wr ~ Year * gcat - 1, data = Stock)
# 3-7-2018#save(gcat.aov,file = 'model-output/gcat.aov.rda')

anova(gcat.aov)
```

```
## Analysis of Variance Table
##
## Response: Wr
##            Df  Sum Sq Mean Sq  F value Pr(>F)
## Year        4 5151406 1287852 7831.673 <2e-16 ***
## gcat        2   20569   10285   62.542 <2e-16 ***
## Year:gcat   6    1513     252    1.533 0.1659
## Residuals 398   65448     164
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

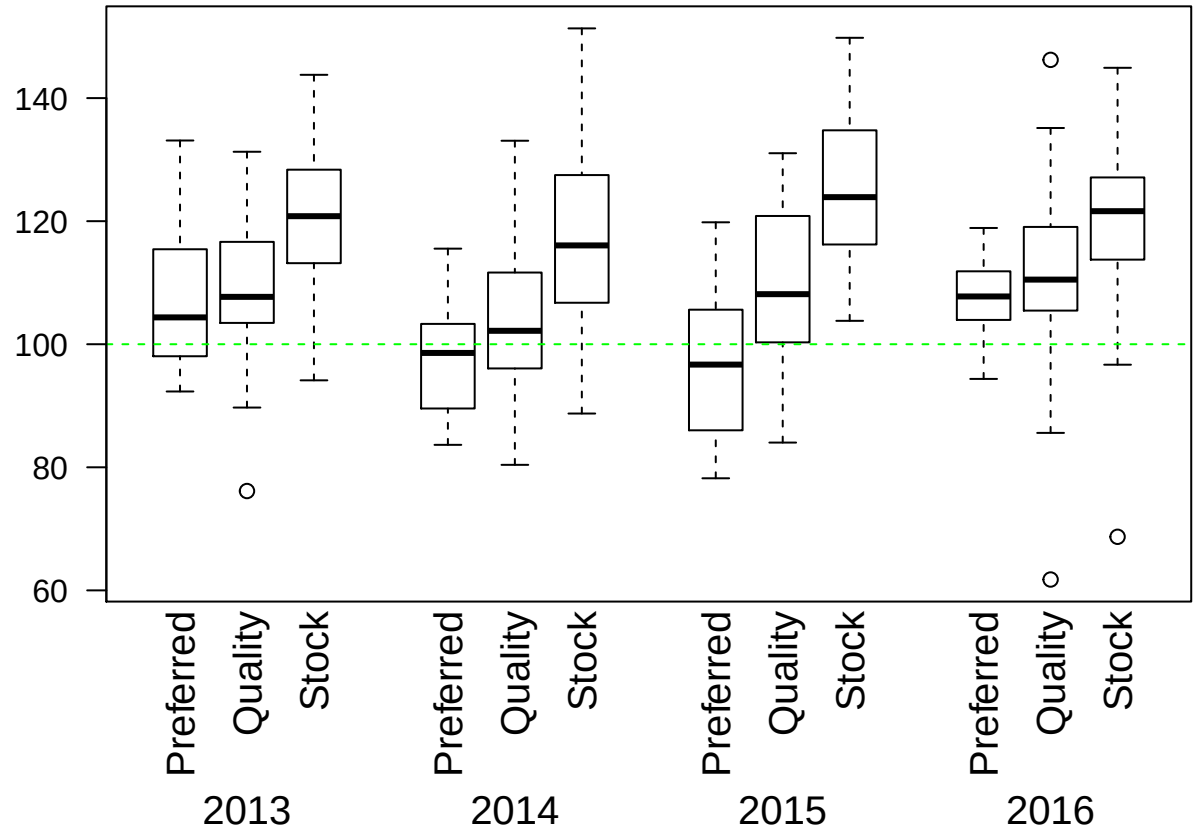
```
# summary(lm(Wr~ Year*gcat -1, data = Stock))
```

```
##                                 diff     lwr    upr p adj
## 2014:preferred-2013:preferred -9.181 -23.667  5.305 0.635
## 2015:preferred-2013:preferred -9.761 -24.913  5.391 0.610
## 2016:preferred-2013:preferred  0.871 -16.125 17.866 1.000
## 2015:preferred-2014:preferred -0.580 -15.319 14.159 1.000
## 2016:preferred-2014:preferred 10.051  -6.576 26.679 0.702
## 2016:preferred-2015:preferred 10.631  -6.580 27.843 0.672
## 2014:quality-2013:quality     -4.690 -13.386  4.006 0.832
## 2015:quality-2013:quality      1.117  -8.434 10.667 1.000
## 2016:quality-2013:quality      3.022  -6.188 12.232 0.995
## 2015:quality-2014:quality      5.807  -3.022 14.636 0.578
## 2016:quality-2014:quality      7.712  -0.748 16.173 0.113
## 2016:quality-2015:quality      1.905  -7.431 11.242 1.000
## 2014:stock-2013:stock         -2.714 -11.122  5.694 0.996
## 2015:stock-2013:stock          3.916  -9.135 16.966 0.998
## 2016:stock-2013:stock         -0.386  -9.191  8.419 1.000
## 2015:stock-2014:stock          6.629  -5.792 19.051 0.841
## 2016:stock-2014:stock          2.328  -5.516 10.172 0.998
## 2016:stock-2015:stock         -4.302 -16.996  8.392 0.994
```

There is *no significant difference* in mean Wr within gabelhouse length categories among years years ($F_{6,398} = 1.53$, p = 0.17).

```
par(mar=c(6.75,4,0.25,0.25))

boxplot(Wr ~ gcat + Year, data=Stock,
        at = c(1,2,3,5,6,7,9,10,11,13,14,15),
        xaxt="n", yaxt="n")

abline(h=100,lty=2,col="green")

mtext(c("Preferred", "Quality", "Stock","Preferred", "Quality", "Stock","Preferred", "Quality", "Stock"
     side = 1,
```

```
     line = 0.25,
     las=2,
     at = c(1,2,3,5,6,7,9,10,11,13,14,15),
     cex = 1.25)

mtext(c("2013", "2014", "2015", "2016"),
     side = 1,
     line = 5,
     at = c(2,6,10,14),
     cex = 1.25)

axis(2,
     at = seq(0,150,20),
     las = 2)
```



Wr between year within gcat

```
Wr.P <- filterD(Stock,gcat=="preferred")

Wr.Q <- filterD(Stock,gcat=="quality")

Wr.S <- filterD(Stock,gcat=="stock")
```

Preferred

```r
WrP.aov <- lm(Wr ~ Year, data = Wr.P)
anova(WrP.aov)
```

```
## Analysis of Variance Table
##
## Response: Wr
##           Df Sum Sq Mean Sq F value   Pr(>F)
## Year       3 1398.1  466.05  4.3125 0.008399 **
## Residuals 55 5943.8  108.07
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```r
WrP.mc <- glht(WrP.aov,mcp(Year="Tukey"))
summary(WrP.mc)
```

```
##
##   Simultaneous Tests for General Linear Hypotheses
##
## Multiple Comparisons of Means: Tukey Contrasts
##
##
## Fit: lm(formula = Wr ~ Year, data = Wr.P)
##
## Linear Hypotheses:
##                   Estimate Std. Error t value Pr(>|t|)
## 2014 - 2013 == 0  -9.1809     3.5719  -2.570   0.0596 .
## 2015 - 2013 == 0  -9.7606     3.7362  -2.612   0.0544 .
## 2016 - 2013 == 0   0.8705     4.1906   0.208   0.9968
## 2015 - 2014 == 0  -0.5797     3.6343  -0.160   0.9985
## 2016 - 2014 == 0  10.0514     4.1001   2.452   0.0787 .
## 2016 - 2015 == 0  10.6311     4.2440   2.505   0.0698 .
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
## (Adjusted p values reported -- single-step method)
```

Quality

```r
WrQ.aov <- lm(Wr ~ Year, data = Wr.Q)
anova(WrQ.aov)
```

```
## Analysis of Variance Table
##
## Response: Wr
##            Df  Sum Sq Mean Sq F value  Pr(>F)
## Year        3  1655.9  551.97  3.4876 0.01701 *
## Residuals 175 27696.7  158.27
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```r
WrQ.mc <- glht(WrQ.aov,mcp(Year="Tukey"))
summary(WrQ.mc)
```

```
##
##   Simultaneous Tests for General Linear Hypotheses
##
## Multiple Comparisons of Means: Tukey Contrasts
##
```

```
##
## Fit: lm(formula = Wr ~ Year, data = Wr.Q)
##
## Linear Hypotheses:
##                   Estimate Std. Error t value Pr(>|t|)
## 2014 - 2013 == 0   -4.690      2.595  -1.808   0.2726
## 2015 - 2013 == 0    1.117      2.850   0.392   0.9795
## 2016 - 2013 == 0    3.022      2.748   1.100   0.6897
## 2015 - 2014 == 0    5.807      2.635   2.204   0.1258
## 2016 - 2014 == 0    7.712      2.525   3.055   0.0137 *
## 2016 - 2015 == 0    1.905      2.786   0.684   0.9029
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
## (Adjusted p values reported -- single-step method)
```

Stock

```
WrS.aov <- lm(Wr ~ Year, data = Wr.S)
anova(WrS.aov)
```

```
## Analysis of Variance Table
##
## Response: Wr
##            Df Sum Sq Mean Sq F value Pr(>F)
## Year        3    584  194.82   1.029 0.3813
## Residuals 168  31807  189.33
```

```
WrS.mc <- glht(WrS.aov,mcp(Year="Tukey"))
summary(WrS.mc)
```

```
##
##   Simultaneous Tests for General Linear Hypotheses
##
## Multiple Comparisons of Means: Tukey Contrasts
##
##
## Fit: lm(formula = Wr ~ Year, data = Wr.S)
##
## Linear Hypotheses:
##                   Estimate Std. Error t value Pr(>|t|)
## 2014 - 2013 == 0  -2.7139     2.7442  -0.989    0.749
## 2015 - 2013 == 0   3.9155     4.2593   0.919    0.789
## 2016 - 2013 == 0  -0.3862     2.8738  -0.134    0.999
## 2015 - 2014 == 0   6.6295     4.0542   1.635    0.353
## 2016 - 2014 == 0   2.3277     2.5600   0.909    0.794
## 2016 - 2015 == 0  -4.3017     4.1430  -1.038    0.720
## (Adjusted p values reported -- single-step method)
```

Wr between gcat within year

I want to see if Wr is different between gcat within each year. Above I show where the relationships of mean Wr for particular gcats between years.

```
Wr.13 <- filterD(Stock,Year==2013)
Wr.14 <- filterD(Stock,Year==2014)
Wr.15 <- filterD(Stock,Year==2015)
```

```
Wr.16 <- filterD(Stock,Year==2016)

str(Wr.13)
```

```
## 'data.frame':    97 obs. of  13 variables:
##  $ fyr   : Factor w/ 1 level "13": 1 1 1 1 1 1 1 1 1 1 ...
##  $ Year  : Factor w/ 1 level "2013": 1 1 1 1 1 1 1 1 1 1 ...
##  $ Site  : int  10 11 11 15 15 15 15 15 18 18 ...
##  $ FID   : int  9 1 8 167 NA 170 176 180 142 141 ...
##  $ Weight: int  807 968 1159 1144 927 982 1015 1000 942 941 ...
##  $ Ws    : num  874 935 1197 859 882 ...
##  $ Wr    : num  92.3 103.6 96.8 133.1 105.2 ...
##  $ Length: int  387 395 426 385 388 401 406 411 381 382 ...
##  $ lcat20: int  380 380 420 380 380 400 400 400 380 380 ...
##  $ gcat  : Factor w/ 3 levels "preferred","quality",..: 1 1 1 1 1 1 1 1 1 1 ...
##  $ Age   : int  4 3 3 3 NA 4 5 5 3 3 ...
##  $ SexCon: int  8 3 3 3 3 8 8 8 8 3 ...
##  $ Sex   : int  2 1 1 1 1 2 2 2 2 1 ...
```

2013

```
Wr13.aov <- lm(Wr ~gcat, data = Wr.13)
anova(Wr13.aov)
```

```
## Analysis of Variance Table
##
## Response: Wr
##           Df  Sum Sq Mean Sq F value    Pr(>F)
## gcat       2  4127.7 2063.87  15.141 1.994e-06 ***
## Residuals 94 12812.8  136.31
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
Wr13.mc <- glht(Wr13.aov,mcp(gcat="Tukey"))
summary(Wr13.mc)
```

```
##
##   Simultaneous Tests for General Linear Hypotheses
##
## Multiple Comparisons of Means: Tukey Contrasts
##
##
## Fit: lm(formula = Wr ~ gcat, data = Wr.13)
##
## Linear Hypotheses:
##                           Estimate Std. Error t value Pr(>|t|)
## quality - preferred == 0    1.351      3.454   0.391 0.918322
## stock - preferred == 0     14.137      3.441   4.108 0.000242 ***
## stock - quality == 0       12.786      2.595   4.928  < 1e-04 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
## (Adjusted p values reported -- single-step method)
```

There is a *Significant* difference in mean Wr between gabelhouse length categories during **2013** ($F_{2,94} = 15.14$, $p < 0.001$). Mean Wr of **Stock** length largemouth bass is *significantly* different from **quality** (Tukey HSD, $t = 4.93$, $p < 0.001$) and **preferred** (Tukey HSD, $t = 4.11$, $p < 0.001$) length largemouth bass.

2014

```
Wr14.aov <- lm(Wr ~gcat, data = Wr.14)
anova(Wr14.aov)
```

```
## Analysis of Variance Table
##
## Response: Wr
##            Df  Sum Sq Mean Sq F value    Pr(>F)
## gcat        2  9565.3  4782.7  26.322 2.121e-10 ***
## Residuals 137 24892.4   181.7
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
Wr14.mc <- glht(Wr14.aov,mcp(gcat="Tukey"))
summary(Wr14.mc)
```

```
##
##   Simultaneous Tests for General Linear Hypotheses
##
## Multiple Comparisons of Means: Tukey Contrasts
##
##
## Fit: lm(formula = Wr ~ gcat, data = Wr.14)
##
## Linear Hypotheses:
##                           Estimate Std. Error t value Pr(>|t|)
## quality - preferred == 0    5.841      3.644   1.603    0.243
## stock - preferred == 0     20.604      3.590   5.739   <1e-04 ***
## stock - quality == 0       14.763      2.446   6.035   <1e-04 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
## (Adjusted p values reported -- single-step method)
```

There is a *Significant* difference in mean Wr between gabelhouse length categories during **2014** ($F_{2,137}$ = 26.32, p < 0.001). Mean Wr of **Stock** length largemouth bass is *significantly* different from **quality** (Tukey HSD, t = 6.04, p < 0.001) and **preferred** (Tukey HSD, t = 5.74, p < 0.001) length largemouth bass.

2015

```
Wr15.aov <- lm(Wr ~gcat, data = Wr.15)
anova(Wr15.aov)
```

```
## Analysis of Variance Table
##
## Response: Wr
##           Df  Sum Sq Mean Sq F value   Pr(>F)
## gcat       2  5625.3 2812.67  17.317 9.75e-07 ***
## Residuals 64 10395.2  162.42
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
Wr15.mc <- glht(Wr15.aov,mcp(gcat="Tukey"))
summary(Wr15.mc)
```

```
##
##   Simultaneous Tests for General Linear Hypotheses
##
```

```
## Multiple Comparisons of Means: Tukey Contrasts
##
##
## Fit: lm(formula = Wr ~ gcat, data = Wr.15)
##
## Linear Hypotheses:
##                           Estimate Std. Error t value Pr(>|t|)
## quality - preferred == 0   12.228      3.886   3.146  0.00689 **
## stock - preferred == 0     27.813      4.736   5.873  < 0.001 ***
## stock - quality == 0       15.585      3.984   3.911  < 0.001 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
## (Adjusted p values reported -- single-step method)
```

There is a *Significant* difference in mean Wr between gabelhouse length categories during **2015** ($F_{2,64} = 17.32$, $p < 0.001$). Mean Wr of **Stock** length largemouth bass is *significantly* different from **quality** (Tukey HSD, t = 3.91, $p < 0.001$) and **preferred** (Tukey HSD, t = 4.74, $p < 0.001$) length largemouth bass as well as **quality** and **preferred** (Tukey HSD, t = , p = 0.007) length largemouth bass.

2016

```
Wr16.aov <- lm(Wr ~gcat, data = Wr.16)
anova(Wr16.aov)
```

```
## Analysis of Variance Table
##
## Response: Wr
##            Df  Sum Sq Mean Sq F value    Pr(>F)
## gcat        2  2763.1 1381.56  8.2031 0.0004946 ***
## Residuals 103 17347.2  168.42
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
Wr16.mc <- glht(Wr16.aov,mcp(gcat="Tukey"))
summary(Wr16.mc)
```

```
##
##   Simultaneous Tests for General Linear Hypotheses
##
## Multiple Comparisons of Means: Tukey Contrasts
##
##
## Fit: lm(formula = Wr ~ gcat, data = Wr.16)
##
## Linear Hypotheses:
##                           Estimate Std. Error t value Pr(>|t|)
## quality - preferred == 0    3.502      4.546   0.770  0.71529
## stock - preferred == 0     12.880      4.481   2.874  0.01277 *
## stock - quality == 0        9.378      2.658   3.528  0.00171 **
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
## (Adjusted p values reported -- single-step method)
```

There is a *Significant* difference in mean Wr between gabelhouse length categories during **2016** ($F_{2,103} = 8.20$, $p < 0.001$). Mean Wr of **Stock** length largemouth bass is *significantly* different from **quality** (Tukey HSD, t = 3.53, p = 0.002) and **preferred** (Tukey HSD, t = 2.87, p = 0.013) length largemouth bass.